Question	Scheme	Marks	AOs
12(a)	$K = 500$	B1	1.1b
	$\tan\alpha = \dfrac{480}{140} \Rightarrow \alpha = ...$	M1	1.1b
	$\alpha =$ awrt $73.74°$ or $500\cos(\theta + 73.74)°$	A1	1.1b
		(3)	
(b)(i)	$R = 1000 + 500\cos(30t + 73.74)°$ or $R = 1000 + 140\cos(30t)° - 480\sin(30t)°$	B1ft	3.3
(b)(ii)	$\{R_{\min} =\} 500$	B1ft	3.4
		(2)	
(c)	$t = 3.5 \Rightarrow R = "1000" + "500"\cos(30(3.5) + "73.74")° = ...$	M1	3.4
	R = awrt 500.1… so the model is reliable	A1	3.5a
		(2)	
(d)	$\sin(30t + 70)° = -1 \Rightarrow 30t + 70 = 270 \Rightarrow 30t = ...$ (or $t = ...$)	M1	3.4
	$30t = 200$ $\left(\text{or } t = \dfrac{20}{3}\right)$	A1	1.1b
	$R = "1000" + "500"\cos\left(30\left("\dfrac{20}{3}"\right) + "73.74"\right)°$ or $R = "1000" + 140\cos("200")° - 480\sin("200")°$	dM1	3.4
	R = 1032 (or 1033)	A1	1.1b
		(4)	
			(11 marks)

Notes

Note: Candidates working in radians are able to score all the M and B marks in this question. Condone the absence of the degrees symbol throughout the whole question.

(a)

B1: Correct value for K. Condone $R = 500$

M1: Award for $\tan\alpha = \pm\dfrac{480}{140} \Rightarrow \alpha = ...$, $\tan\alpha = \pm\dfrac{140}{480} \Rightarrow \alpha = ...$, $\sin\alpha = \pm\dfrac{480}{"500"} \Rightarrow \alpha = ...$ or $\cos\alpha = \pm\dfrac{140}{"500"} \Rightarrow \alpha = ...$

Note $\alpha =$ awrt 1.3 (rad) implies this mark.

A1: $\alpha =$ awrt $73.74\{°\}$ or correct expression $500\cos(\theta + 73.74)\{°\}$

(b)(i) Note: mark parts (b)(i) and (b)(ii) together.

B1ft: Correct equation of the model in either form including the R = following through on their numerical K ($0 < K$,, 750) and their numerical α.

Allow for e.g. $R = 1500 - "500" + "500"\cos(30t + "73.74")\{°\}$ or for $R = 1500 - "500" + 140\cos(30t)° - 480\sin(30t)°$ but not e.g. $R = 1500 - K + K\cos(30t + \alpha)°$

$R = 1000 + 140\cos 30t - 480\sin 30t$ (without the brackets) is correct.

Allow this mark if they have truncated or rounded an otherwise correct α (to 3s.f.)

(b)(ii)

B1ft: 500 or follow through on (their A – their K) or (1500 – 2 × their K) provided it is non-negative and less than 1500. It must be clear this is their answer to (b)(ii) so expect to see e.g. (b) or $R_{\min} =$ or an indication it is the minimum.

(c) Note: if θ is used in place of $30t$ then they must revert back to $30t$ correctly to access the marks.

M1: Substitutes $t = 3.5$ into their model for the number of rabbits (you may need to check if no method is shown)

or substitutes $t = 3.5$ into their $\cos(30t + \alpha)°$

Condone substitution of a value of t in the range $3 \text{ ,, } t \text{ ,, } 4.5$ for this mark.

A1: R = awrt 500.1… **or** 500 (not awrt) following substitution of $t = 3.5$, suggesting that the model is valid/reliable/appropriate/good.

or $\cos(30(3.5) + 73.74)\{°\} \approx -1$ suggesting that the model is valid/reliable/appropriate/good.

Allow this mark if they have truncated or rounded an otherwise correct α (to 3s.f.)

Alt:

M1: Minimum occurs when $A + K\cos(30t + \alpha)° = R_{\min} \Rightarrow \cos(30t + \alpha)° = \lambda$ with $|\lambda| \text{ ,, } 1$ leading to $t = ...$

May just see $\cos(30t + 73.74)° = -1 \Rightarrow t = ...$ (or their $\cos(30t + \alpha)° = -1 \Rightarrow t = ...$)

$30t + \alpha = 180 \Rightarrow t = ...$ implies this mark. Condone $30t + \alpha = \pi \Rightarrow t = ...$ for this mark.

A1: $t = 3.54...$ (i.e. the middle of April) so the model is valid/reliable/appropriate/good.

Do not condone incorrect statements, e.g., $t = 3.54...$ i.e. the middle of March so close to middle of April. If using $A + K\cos(30t + \alpha)° = R_{\min}$ then $R_{\min}$ must be = their A – their K

Allow this mark if they have truncated or rounded an otherwise correct α (to 3s.f.)

Alt 2 using differentiation (Condoned)

M1: Condone finding the minimum using $...\sin(30t + 73.74)° = 0 \Rightarrow t = ...$ (or their $\sin(30t + \alpha)° = 0 \Rightarrow t = ...$)

$30t + \alpha = 180 \Rightarrow t = ...$ implies this mark. Condone $30t + \alpha = \pi \Rightarrow t = ...$ for this mark.

A1: $t = 3.54...$ (i.e. the middle of April) suggesting that the model is valid/reliable/appropriate.

Do not condone incorrect statements, e.g., $t = 3.54...$ i.e. the middle of March so close to middle of April.

The complete derivative for $\frac{\mathrm{d}R}{\mathrm{d}t}$ does not need to be seen.

Allow this mark if they have truncated or rounded an otherwise correct α (to 3s.f.)

(d) Note: if θ is used in place of $30t$ then they must revert back to $30t$ correctly to access the marks.

M1: Realises that $\sin(30t + 70)° = -1$, reaches $30t + 70 = 270$ or –90 and attempts to find t (or $30t$)

Condone attempts using differentiation. The minimum occurs when $\cos(30t + 70)° = 0 \Rightarrow$ $30t + 70 = 270 \Rightarrow 30t = ...$ (or $t = \ldots$). They must use 270 or –90 and **not** 90 to achieve the minimum. Condone $30t + \alpha = \frac{3\pi}{2} \Rightarrow t = ...$ for this mark but not $30t + \alpha = \frac{\pi}{2} \Rightarrow t = ...$

A1: Correct value for $30t$ (or t) Accept rounded or truncated values to at least 3s.f. e.g. 6.66 or 6.67

dM1: Substitutes their value of $t > 0$ (or $30t > 0$) coming from $30t + 70 =$ **270** into their model for R

A1: Correct number of rabbits. Allow 1032 or 1033 but must be whole numbers and not just 1030.

Allow this mark if they have truncated or rounded an otherwise correct α (to 3s.f.)